Application

Kennecott
Eagle Minerals

Humboldt Tailings Disposal Facility Inland Lakes and Streams Permit Application

Project I.D.: 06W003

Kennecott Eagle Minerals Company
Ishpeming, Michigan

December 2008

Foth

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Kennecott
Eagle Minerals

December 15, 2008

Michigan Department of Environmental Quality
Land and Water Management Division
Permit Consolidation Unit
525 W. Allegan Street
1st Floor South Tower
Lansing, Michigan 48933

Re: Humboldt Tailings Disposal Facility – Joint Permit Application for an Inland Lakes and Streams Permit

This Michigan Department of Environmental Quality (MDEQ) and United States Army Corp of Engineers (USACE) Joint Permit Application has been prepared to provide information to evaluate the Kennecott Eagle Minerals Company (KEMC) proposed tailings management project for approval of an Inland Lakes and Streams Permit. This document was prepared in accordance with Part 301 of Michigan's Natural Resources and Environmental Protection Act and MDEQ instructions.

The proposed tailings management project will take place in the existing Humboldt Tailings Disposal Facility that contains sulfide tailings from previous operators. The proposed action includes engineering improvements to the existing facility, in addition to subaqueous tailings placement generated from milling operations at the Humboldt Mill.

This application and associated appendices provide the following information:

- The MDEQ and USACE Joint Permit Application.
- Maps, drawings, aerial photographs, and project site plan.
- Letters from two associated property owners authorizing KEMC to apply for this permit.
- A permit application fee of $2,000 to the State of Michigan.
- Associated information and explanation describing the project to assist in reviewing the proposed action.

A tentative construction schedule developed for project planning estimates an 18 to 24 month project construction schedule beginning in mid 2009. Milling is planned to commence in 2010 or 2011. KEMC is a subsidiary of Rio Tinto headquartered in London. Rio Tinto develops, manages, operates, and participates in base metal and precious metals mining operations in North America and around the world.

Thank you for your assistance in review of this document. If you need additional information or have questions, please contact me at (906) 486-1257.

Sincerely,

Kennecott Eagle Minerals Company

Jonathan C. Cherry, P.E.
General Manager

cc: Joe Derocha, Humboldt Township Supervisor, w/o enclosure
Steve Power, Marquette County, w/o enclosure

Distribution List

No. of Copies	Sent to:
4	Michigan Department of Environmental Quality LWMD-PCU P.O. Box 30204 Lansing, MI 48909-7704
2	Mr. Gene Smary Warner Norcross & Judd LLP 900 Fifth Third Center 111 Lyon St. N.W. Grand Rapids, MI 49503-2489
2	Mr. Joe Maki District Geologist Michigan Department of Environmental Quality 420 5th St. Gwinn, MI 49841
2	Mr. Hal Fitch Chief State Geologist OGS Michigan Department of Environmental Quality Constitution Hall, 3rd Floor North 525 W. Allegan St. Lansing, MI 48909
4	Mr. Jonathan Cherry Kennecott Eagle Minerals Company 504 Spruce Street Ishpeming, MI 49849

Foth

December 12, 2008

Mr. Jonathan Cherry
Kennecott Eagle Minerals Company
504 Spruce Street
Ishpeming, MI 49849

Dear Mr. Cherry,

Re: Humboldt Tailings Disposal Facility – Inland Lakes and Streams Permit Application

Enclosed for your distribution is the Humboldt Tailings Inland Lakes and Streams Application. This application has been prepared according to the requirements of Part 301 of the Michigan Natural Resources Environmental Protection Act, and Administrative Rules codified under R 324.30101 et. seq.

Sincerely,

Foth Infrastructure & Environment, LLC

Stephen V. Donohue, P.H.
Project Director

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Humboldt Tailings Disposal Facility
Inland Lakes and Streams Permit Application

Project ID: 06W003

Prepared for
Kennecott Eagle Minerals Company
ISO 14001:2004 Registered System

Prepared by
Foth Infrastructure & Environment, LLC

December 2008

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Humboldt Mill
Inland Lakes and Streams Permit Application

Contents

Page

Contents *(continued)*

Tables

(Tables located after Tables tab)

Figures

(Figures located after Figures tab)

Appendices

List of Abbreviations, Acronyms, and Symbols

ARD	Acid Rock Drainage
bgs	below ground surface
CR	County Road
cy	cubic yards
FEMA	Federal Emergency Management Agency
ft	Feet
ft^3	cubic feet
Foth	Foth Infrastructure & Environment, LLC
gpm	gallons per minute
HDPE	high density polyethylene
hr	Hour
HTDF	Humboldt Tailings Disposal Facility
JPA	joint permit application
KEMC	Kennecott Eagle Minerals Company
LWMD	Land and Water Management Division
m^2	square meters
m^3	cubic meters
MDEQ	Michigan Department of Environmental Quality
MEND	Mine Environment Neutral Drainage
mg/l	milligrams per liter
MI	Michigan
m	Meter
No.	Number
NPDES	National Pollutant Discharge Elimination System
NRCan	Natural Resources Canada
NREPA	Natural Resources and Environmental Protection Act
OHWM	Ordinary High Water Mark
%	Percent
R	Rule
SESC	Soil Erosion and Sediment Control
tonne	metric ton (1 tonne = 1.1 ton)
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant
yr	Year

1. Introduction

Kennecott Eagle Minerals Company (KEMC) is proposing to reuse the existing Humboldt Tailings Disposal Facility (HTDF) located in Humboldt Township, Marquette County, Michigan. The HTDF is located approximately 24 miles west of Marquette, Michigan, as shown in Figure 1-1. The HTDF will be refurbished for placement of tailings from the processing of copper and nickel ore.

The HTDF is an excavated water-filled iron mine that was converted to a tailings disposal and treatment facility during milling operations in the late 1980s. The HTDF appears on the site plan of existing conditions shown in Figure 1-2. The HTDF will be recommissioned to accept the tailings from the proposed milling operation. A site development plan for the overall project appears in Figure 1-3.

A permit to place tailings in the HTDF is sought in this application as required under Part 301 - Inland Lakes and Streams of Michigan's Natural Resources and Environmental Protection Act (NREPA). The permit application appears in Appendix A and has been prepared using the Michigan Department of Environmental Quality (MDEQ) and United States Army Corps of Engineers (USACE) Joint Permit Application (JPA) as provided by the MDEQ Land and Water Management Division (LWMD) and the Joint Permit Application Training Manual.

1.1 Background Information

Mining activity has taken place on the project site since 1954. The project site is considered a brownfield site by the United States Environmental Protection Agency (USEPA) as defined in the 2002, Public Law 107-118; H.R. 2869 to include mine-scarred lands. Mine-scarred lands are defined as lands, associated waters, and surrounding watersheds where extraction, beneficiation, or processing of ores and minerals has occurred (USEPA, 2004). Although this property is eligible for benefits under the USEPA's Brownfields Program, KEMC is pursuing the environmental improvement and use of this property without federal assistance.

The property is located in Sections 2 and 11 in Township 47 North, Range 29 West, Humboldt Township, Marquette County, Michigan. The facility street address is 4547 County Road (CR) 601. The facility is accessed via an entrance off CR 601. The regional setting, including property ownership surrounding the HTDF, is shown in Figure 1-2. As shown in Figure 1-4, the project lies in the Escanaba Watershed, which drains into Lake Michigan.

Originally, the site was developed as an underground iron ore mine, followed by open pit extraction. A total of approximately 12,000,000 cy of rock was removed from the Humboldt Mine (now the HTDF). A mill was built adjacent to the mine to process the iron ore. When mining ceased in 1970, the excavated pit was allowed to fill with water. At that time, the maximum depth of the Humboldt Mine was approximately 350 ft.

In the early 1980s, Callahan Mining Corporation developed the Ropes Gold Mine, approximately ten miles east of the HTDF (see Figure 1-1). At that time, Callahan Mining Corporation purchased the Humboldt Mill and converted it to process ore from the Ropes Gold Mine. The mill processed gold bearing sulfide ore from approximately 1985 until 1989 when the Ropes Mine closed. To accommodate the tailings, the excavated Humboldt Mine was permitted and used as a tailings disposal and treatment facility. Approximately 1.82 million tons of tailings from the Ropes Mine were placed in the HTDF. As such, the HTDF is a pre-existing disposal facility and its future use will be regulated under Part 632, Part 301 and Part 31 of NREPA. By definition under Part 632, the HTDF is a "*tailings basin…on which is deposited by hydraulic or other means, the material that is separated from the metallic product in the benefication or treatment of minerals including any surrounding dikes constructed to contain the materials.*" Furthermore as defined under R 425.102(k), the HTDF is a "*disposal facility … where … tailings are intentionally placed into or on the land… and at which the tailings will remain after closure.*" In addition, the HTDF is a manmade structure used solely for the conveyance treatment and control of wastewater and per R 323.1044(v) does not meet the definition of surface waters of the state as it relates to the placement of new tailings in the HTDF.

During the milling operations of ore from the Ropes Mine, surface water released from the HTDF was regulated via a National Pollutant Discharge Elimination System (NPDES) permit (Permit No. MI0044393). This permit has been inactive since 1997.

Kennecott presently owns approximately 26.7 acres of property around the mill and has options to purchase approximately 135.5 acres from O'Dovero Properties and approximately 187.5 acres from Callahan Mining Corporation, totaling approximately 349.7 acres.

1.2 Regulatory Applicability

Under Part 301 of NREPA, an Inland Lakes and Streams Permit is required for activities that occur within or over an inland lake or below the Ordinary High Water Mark (OHWM) of an inland lake. An inland lake is a natural or artificial lake, pond or impoundment five acres or greater. The HTDF is an artificial water feature covering approximately 67 acres, and therefore an Inland Lakes and Streams Permit is required under Part 301 for tailings placement in the HTDF. Currently no delineated wetlands are to be affected by any of the proposed construction activities. Therefore, a permit under Part 303 of NREPA is not required.

1.3 Application Organization

The USACE – MDEQ JPA form is found in Appendix A of this application. Additional explanation and supporting information for each applicable section of the application form is found in Section 2 of this application report. Supporting figures are found following the application text of this report.

1.4 Other Permits

KEMC is applying for other related permits required to use the HTDF for tailings placement. These applications are contained under separate cover in the format required by the respective regulatory agency departments. These permit applications and related regulatory documents are as follows:

- A *Mining Permit Application* (MPA) (Foth, 2008a) to be submitted to the MDEQ for processing of nonferrous metallic ore and disposal of tailings.

- A *National Pollutant Discharge Elimination System Permit Application* (Foth, 2008b) to be submitted to the MDEQ for water discharge from the HTDF.

- A *Part 91 Soil Erosion and Sedimentation Control Permit Application* (SESC) (Foth, 2008c) to be submitted to the Marquette County for construction stormwater.

- A *Notice of Coverage* for storm water management during construction activities to be submitted to the MDEQ after KEMC receives the SESC permit.

2. Application Supporting Information

The following sections address each section of the USACE – MDEQ JPA. Section headings are listed in numerical order according to the section number on the application form.

2.1 Project Location Information

The project location is in Marquette County as listed. Further information is provided in Section 1 and Figure 1-1.

The proposed project type includes a tailings disposal facility for an ore beneficiation process. The HTDF is proposed to be recommissioned to accept tailings from milling.

Based on a Federal Emergency Management Agency (FEMA) map search performed by Foth on June 25, 2007, no floodplain mapping has been completed for this area. The wetlands identified to receive discharge from the HTDF will be through a controlled point of discharge that includes provisions for water treatment, if necessary. As described in this application, the proposed project construction and operational activities will not change or affect the hydrology of the Middle Branch Escanaba River. Therefore the existing floodplains of this river will not be affected by the project.

2.2 Description of Project, Associated Activities, and Construction Sequence and Methods

KEMC is proposing to rehabilitate the existing HTDF and associated mill to process nickel and copper ore. The milling operation will produce tailings, proposed to be placed in the HTDF currently located on the property. The HTDF will be recommissioned to accept the tailings from the proposed milling operation. An overall site development plan of the proposed project is shown in Figure 1-3.

Facilities for the planned project include:

- A coarse ore storage area for ore storage and primary crushing operations (new),
- A secondary crusher building (new),
- The office and maintenance building (renovated),
- The mill building (renovated),
- A well and sanitary system (new),
- Access and vehicle parking areas (new bituminous area),
- Site infrastructure including rail spur, paved areas for parking and truck access,
- The HTDF (recommissioned),
- A wastewater treatment plant (WWTP) for treating discharge water from the HTDF (new),
- A concentrate load-out building (new),
- A cut-off wall in the unconsolidated deposits on the north side (outlet) of the HTDF,
- Tailings slurry and WWTP influent and effluent pipelines (new), and
- Surface water control structures, including ditches and culverts and sedimentation basin (new).

KEMC has conducted a detailed analysis of the existing HTDF as documented in Appendix B. The analysis includes water balance estimates, chemical characterization of the existing water quality and potential changes as a result of tailings loading. Additional studies on pertinent wetlands and aquatic biota are provided in Appendix C.

During mill operations, discharge of tailings to the HTDF via slurry is expected to be approximately 225 gallons per minute (gpm) of slurry (water and solids). The slurry will contain tailings at approximately 60% solids, and will be pumped via double-walled high density polyethylene (HDPE) pipe to the HTDF. Reclaimed water from the HTDF, as well as other mill water, will be used to create the slurry. The tailings will be subaqueously placed at the base of the HTDF pipeline connected to a diffuser at the discharge outlet. The diffuser at the discharge will reduce the slurry velocity to minimize disturbance and re-suspension of existing placed tailings. The tailings are expected to consolidate to approximately 72% solids.

The expected daily design loading of tailings to the HTDF during operation will be approximately 1,160 tonnes (dry weight). Expected annual solids loading to the HTDF will be approximately 123,000 to 371,000 tonnes (dry weight). Total quantity of tailings that will be disposed of in the HTDF is approximately 2.5 million tonnes.

Tailings will be placed in three separate phase areas beginning in the North (Phase 1) progressing to the south (Phase 2, Phase 3). The HTDF phase development plan is shown in Figure 2-1. The tailings slurry will be subaqueously placed at the bottom in a controlled manner to allow solids accumulation in layers across the floor. Figure 2-2 displays slurry pipeline design features for controlled tailings placement. This will be accomplished with the use of a floating barge having a discharge boom that can be positioned vertically across the floor. This approach to placement of tailings will reduce physical mounding. The total estimated volume available in the three areas to elevation 1,475 ft is approximately 5,000,000 cy. Assuming the tailings consolidate to 72% solids, estimated required tailings disposal volume is 2,400,000 cy. Leveling of the tailings after placement will occur over a period of time, due to consolidation and gravity. The surface elevation of the tailings, if complete leveling is assumed, will be near elevation 1,420 ft, leaving approximately 118 ft of water over the tailings, assuming a surface water elevation of 1,538 ft (Figures 2-3 and 2-4).

As a result of the tailings loading, approximately 13,500 ft^3 of water per day will be displaced from the HTDF during operations. Over the operating period, approximately 175,000,000 to 200,000,000 ft^3 of water will be released in a controlled manner from the HTDF. This includes water displaced from tailings placement and water released from natural precipitation events. Excess water from the HTDF will be treated at the WWTP, if necessary, before discharging to a wetland north of the HTDF.

To prevent HTDF water from mixing with surface water and groundwater present in the alluvial deposits (primarily a mixture of sands and gravels) at the north end of the HTDF, KEMC will construct a containment berm and a low permeability cut-off wall at the location shown on Figures 2-1 and 2-5. The containment berm and cut-off wall will prevent subsurface and surface discharge from the north side of the HTDF during operations and also provide storage capacity. The containment berm will be removed after closure as described in the MPA (Foth, 2008a). The cut-off wall will extend approximately 1,800 linear ft and will be keyed to the bedrock outcrop near elevation 1,543 ft. Based upon past geophysical surveys conducted in this area, the soils extend to a depth averaging approximately 40 to 50 ft (Traverse Engineers Services, 1984). The cut-off wall will be extended to bedrock along this alignment. Cross-sections through the HTDF are shown on Figures 2-3 and 2-4.

KEMC is considering different cut-off wall construction techniques, including cut/fill methods and vibratory beam injection methods. Both of these methods have been successfully used in similar type conditions. As shown on Figures 2-1 and 2-5, some grading will be needed at the north perimeter of the HTDF to establish a surface elevation at or above elevation 1,543. By meeting that elevation, the HTDF exceeds the capacity required for a 24 hr, 100-yr storm event. A 24 hr, 100-yr storm event would require 1.2 ft of added storage capacity for the HTDF. For example, assuming a water elevation of 1,538.5 ft, a 24 hr, 100-yr storm event would result in a peak water level of 1,539.7 ft, less than the containment elevation of 1,543 ft.

2.3 Applicant and Property Owner Information

Property ownership is shown on Figure 1-2. The HTDF is currently owned by Callahan Mining Corporation, a wholly-owned subsidiary of Coeur d'Alene Mines Corporation. KEMC has an option to purchase this land. The Callahan point of contact is:

Coeur d'Alene Mines Corporation
Attn: Mr. Luke Russell
400 Coeur d'Alene Mines Bldg.
505 Front Ave.
Coeur d'Alene, ID 83816-0316
Telephone: 208-667-3511

Adjacent land surrounding the mill is owned by O'Dovero Properties. KEMC has an option to purchase this land. The point of contact at O'Dovero Properties is:

Mr. Peter O'Dovero
O'Dovero Properties
110 Airport Rd
Negaunee, MI 49866
Telephone: 906-225-7040

Letters of authorization from the land owners listed above are provided in Appendix D.

2.4 Proposed Project Purpose, Intended Use, and Alternatives Considered

The recommissioning of the HTDF provides a processing facility. The intended use of the facility is to process copper and nickel ore. This ore can produce sulfide tailings that may potentially oxidize. Tailings will be sent in slurry form to the anoxic environment at the bottom of the HTDF to minimize the potential for tailings oxidation and related environmental impacts. Placement in an anoxic environment, such as under water, provided the water cover is of sufficient depth to prevent resuspension and is not subject to seasonal disappearance, is recognized in the mining industry as a best practice to store sulfide tailings (Mend, 1997b). The design of the HTDF protects public health and welfare, and the environment by preventing the release of contaminants of concern. Placement of tailings at depth in the HTDF will minimize potential oxidation of the tailings and minimize impacts on water quality in the HTDF, including the surface water discharge that will occur upon placement of the tailings.

2.4.1 Alternatives Analysis

Processing ore will generate mill tailings. Tailings are the ground up host rock that remains after metals of interest are separated as product. Over the life of the project, a total of approximately 2.5 million tonnes (2.75 million tons) of total dry weight tailings will be produced from ore processing and will require safe and stable storage in a manner that provides environmental protection. Mill tailings present challenges affecting the efficient operation of mills. Tailings mass and volume are often large and need to be managed in a safe and stable manner. Several approaches are available for management of tailings ranging from: surface placement of tailings in an engineered facility equipped with a liner and cover system, mixing the mill tailings with a binder (usually cement) to create a paste for use as backfill in the mine of origin, and subaqueous disposal. In considering these alternatives, it is necessary that the chemistry of how tailings interact with the natural environment be considered.

2.4.1.1 Tailings Geochemistry and Management Alternatives

Geochemical Processes
Natural weathering of rock is a part of the geochemical cycling of elements, and tailings from many types of mining participate in this process. The chemistry of the weathering of tailings begins through simple dissolution reactions and is often limited by the low solubility of many mineral phases. However, tailings produced by the milling of sulfide minerals present additional management challenges because of the possibility of oxidation of reduced sulfur (sulfide) to more oxidized forms, such as sulfate. This dissolution and oxidation process can occur when sulfide tails are exposed to atmospheric oxygen and water.

Sulfide oxidation may cause the release of metals in sulfide tailings. In the presence of water and atmospheric oxygen, the oxidation reaction removes sulfide from solution, and so enhances dissolution reactions of sulfide minerals. In addition, oxidation of sulfide minerals can produce acidity, through both oxidation of sulfide and formation of metal oxy-hydroxides and sulfate hydroxides. If the acidity from these reactions is not neutralized, solution pH will decrease, often leading to additional dissolution of mineral solid phases. Interrupting or preventing this cycle requires tailings management based on an understanding of the chemistry of sulfide oxidation.

The importance of proper management of sulfide tailings and the possibility of acid rock drainage (ARD) from the tailings of sulfide ores has long been recognized, and much progress has been made in describing the chemistry of sulfide mineral oxidation and ARD formation (e.g., Temple and Delchamps, 1953; Singer and Stumm, 1970; Nordstrom, 1982; Nicholson et al., 1988; Blowes and Jambor, 1990; Elberling and Damgaard, 2001; Herbert and Schippers, 2008). It is now known that oxidation of sulfide minerals is a biogeochemical process that is affected by many variables, including the composition of ore. Because of its abundance, pyrite (FeS_2) is often used as a model when describing sulfide mineral oxidation. The following equations show the major reactions that may occur during the oxidation of pyrite (Peinerud, 2003):

$$FeS_2 + \frac{7}{2}O_2 + H_2O = Fe^{2+} + 2SO_4{}^{2-} + 2H^+ \qquad (1)$$

$$Fe^{2+} + \frac{1}{4}O_2 + H^+ = Fe^{3+} + \frac{1}{2}H_2O \quad (2)$$

$$FeS_2 + 14Fe^{3+} + 8H_2O = 15Fe^{2+} + 2SO_4{}^{2-} + 16H^+ \quad (3)$$

$$2Fe^{2+} + \frac{1}{2}O_2 + 5H_2O = 2Fe(OH)_3 + 4H^+ \quad (4)$$

$$Fe^{3+} + 3H_2O = Fe(OH)_3 + 3H^+ \quad (5)$$

The oxidation of sulfide minerals is a complex process and the above reactions do not represent a reaction scheme. Instead these reactions capture the types of chemistry that may occur as pyrite (or other sulfide minerals) is oxidized.

Pyrite oxidation is sometimes viewed as occurring in a system that has reached chemical equilibrium; this is best represented by summing Equations 1 and 4 (after dividing Equation 4 by 2):

$$FeS_2 + \frac{15}{4}O_2 + \frac{7}{2}H_2O = Fe(OH)_3 + 2SO_4{}^{2-} + 4H^+ \quad (6)$$

Equation 6 is often presented as the chemical equation describing pyrite oxidation, but this is an over-simplification largely because of the assumption of chemical equilibrium (Morin, 1990). In an open system with mass flow (i.e., water and oxygen moving through the tailings), products of one reaction may become reactants of another reaction, and mass may leave the system. Under these more realistic assumptions, oxidation of sulfide minerals is viewed as an ongoing process, the rate of which is controlled by chemical kinetics. Management of oxidation is then based on directing chemical reactions towards steady-state conditions where oxidation is minimized. In practice, minimizing oxidation requires limiting the availability of water or oxygen, as one or both of these reactants are essential components of the reactions shown above.

Dry Storage

Limiting exposure of sulfide tailings to water is referred to as dry storage. The feasibility of this approach may depend on the environmental characteristics of the disposal site. Tailings must be placed at an elevation that will always remain above the water table, and tailings must be shielded from atmospheric moisture. After placement at an appropriate elevated location, tailings may be shielded from precipitation through a variety of cover options, as is often done with solid waste disposal facilities. Covers will also limit exposure of tailings to atmospheric oxygen. This is an effective strategy for safe and stable management of tailings.

Subaqueous Storage

Oxidation of sulfide tailings may also be reduced by limiting exposure to atmospheric oxygen. Ongoing research, including extensive field studies, has shown that the best way to reduce oxygen exposure is through the use of a water cover (e.g., Moses and Herman, 1989; Robertson, 1991; Morin, 1993; Pedersen et al., 1993; Fraser and Robertson, 1994; Peacey et al., 2002).

Water covers over tailings may take many forms depending on implementation, but in all cases this management practice is referred to as subaqueous disposal. A recent literature review of water covers is provided by Peinerud (2003). Also, the Mine Environment Neutral Drainage (MEND) program of Natural Resources Canada (NRCan) directed research on subaqueous disposal of sulfide tailings between 1988 and 2000 and has published many reports and reviews describing this work. Titles of MEND review manuscripts are provided above in Section 4; a more extensive listing is found on the MEND web site (http://mend2000.nrcan.gc.ca). Research such as that conducted by the MEND Program has demonstrated that water covers are the preferred method for sulfide tailings disposal, if a suitable water repository is available.

The effectiveness of water covers as an oxygen barrier is a direct consequence of the low solubility and diffusivity of oxygen in water relative to air. Even when water is fully saturated with dissolved oxygen, the concentration of oxygen in water is about 25,000 times less than that in air, on a mass basis under typical ambient conditions. As Equation 6 shows, a closed pyrite-sulfate system at equilibrium moves toward pyrite as oxygen concentration decreases, and so, decreasing available oxygen will reduce the oxidation of pyrite. While equilibrium will not be obtained in an open system such as a subaqueous tailings disposal facility, the effectiveness of water covers is, to a first approximation, well explained by the large decrease in oxygen concentrations between air and water.

Subaqueous sulfide tailings disposal facilities are open to atmospheric oxygen and contain large quantities of reduced sulfur; thus, these systems are not at equilibrium. Given the low solubility of oxygen in water, the extent of sulfide oxidation will depend on the availability of oxygen. Dissolved oxygen in water at the water-tailings interface will be consumed as the chemistry represented by Equations 1, 2 and 4 proceeds, and a concentration gradient will, therefore, always be present over the depth of a water cover. Atmospheric oxygen will be drawn along this gradient towards the submerged tailings.

The minimum rate at which oxygen advances along the concentration gradient is set by the diffusivity of oxygen in water. Oxygen diffusivity in water is about 10,000 times lower than in air, so, as with solubility, water forms a very effective barrier preventing sulfide tailings oxidation, relative to tailings exposed to the atmosphere.

Molecular diffusivity sets the minimum rate at which oxygen may be replenished in water. The actual rate at which oxygen is replenished in water near the water-tailings interface in a subaqueous disposal facility (and, therefore, the rate at which tailings oxidize) will depend on a number of factors, such as the water depth, and the amount of turbulence in both the water and the atmosphere (often set by the wind speed). Each of these variables has been examined in field and laboratory settings, and many of these studies are presented in the MEND references. An important conclusion of this work is that, in many settings, as little as one to two meters of water depth will provide a very effective cover over sulfide tailings, even given the effects of wind-induced turbulence and the possibility of tailings resuspension. Elberling and Damgaard (2001) have also shown that the rate of oxygen consumption (and so, the rate of tailings oxidation) is not constant, but decreases with increasing age of submerged tailings. This is attributed to the formation of a thin veneer (millimeter-scale) of oxidized tailings at the water-tailings interface. Considered as a whole, the results of the field and laboratory investigations show that water covers of only a few meters depth can reduce sulfide tailings oxidation rates by several orders of magnitude relative to tailings exposed to the atmosphere.

As the depth of a water cover increases, other physical and chemical processes may begin to operate in a subaqueous disposal facility. These processes can further reduce not only the extent of sulfide oxidation, but also the transport of dissolved metals that may be released by oxidation of tailings. Two important processes are the formation of an anoxic hypolimnion and the cycling of reduced and oxidized iron.

The bottom waters of a water cover may become either seasonally or permanently anoxic if a subaqueous disposal facility is of sufficient depth; the necessary depth will depend on basin morphology and turbulence resulting from wind and flow. The lack of oxygen in bottom waters will divide the water column and further prevent oxygen from reaching submerged tailings, thus creating a very stable reducing environment where sulfide oxidation will be very slow. Any small quantity of oxygen that does reach this zone will be consumed by reduced sulfur, and sulfide tailings will therefore be self-stabilizing.

Dissolved metals that can exist in multiple redox states will be in a reduced state in this anoxic environment. As sulfide tailings will often contain iron sulfides, reduced iron will be present in the water covering the tailings, and a reduced-oxidized iron cycle may be established.

Iron cycling is often observed in natural waters that develop an anoxic hypolimnion. The cycle begins as reduced iron diffuses upward and crosses into the oxygenated epilimnion. The reduced iron is then oxidized by dissolved oxygen, as shown in Equation 2. If the water pH is circumneutral, as is most often the case if carbonate minerals are present, the oxidized iron will form hydroxides (Equation 5). As these amorphous solids coagulate and flocculate, iron hydroxide particles will settle back toward the anoxic bottom waters. The iron may again be reduced, either in the water column or after reaching the sediments. The newly formed reduced iron is then available to continue the cycle (Stumm and Morgan, 1996).

The iron cycle can regulate the concentration of other dissolved chemicals because iron hydroxide particles have very active surfaces that will adsorb (through complex formation) many chemical species, particularly dissolved metals (Buffle and De Vitre, 1994). Thus, iron hydroxides particles will sweep the water column of dissolved metals as they settle toward the sediments, and so reduce dissolved metal concentrations. In this way, the iron cycle can form a barrier preventing upward diffusion of dissolved metals and limit transport of these metals from the subaqueous disposal facility.

A number of case studies of subaqueous disposal of sulfide tailings have been documented in the literature; many of these studies are discussed in the MEND Program references.

An example of a subaqueous disposal facility with a shallow water cover is provided by the Stekenjokk tailings pond, created by flooding the tailings impoundment associated with the Stekenjokk copper and zinc mine (Holmström and Öhlander, 1999). The pond contains approximately four million tons of tailings that contain about 20% sulfur. Average water depth in the tailings pond is 2.5 meters. While some oxidation of tailings has been observed as tailings were allowed to oxidize prior to placement of the water cover, a sulfate mass balance indicates that only a small amount of reduced sulfur has been oxidized, with most sulfate coming from dissolution of gypsum. Based on these results, the water cover has exceeded its design specifications and is viewed as a successful example of a water cover. Additional work

(Holmström and Öhlander, 2001) has also shown that water column concentrations of many metals, such as copper, lead and zinc, are reduced because of association with iron and manganese oxyhydroxides, through a process similar to iron cycling.

Pedersen et al. (1997) discuss the use of two natural lakes as water covers for tailings management. No evidence of sulfide oxidation of tailings has been observed in Anderson Lake, Manitoba, even in those areas of the lake with oxygenated waters. Sulfide oxidation may be reduced by the high concentration of organic carbon in the lake sediments. Metal profiles indicate that metals are moving into the sediments from the water column. A similar process may be operating in Butte Lake, British Columbia, as natural sediments continually cover tailings deposited ten years before this study. No oxidation of these tailings has been observed.

Paste Backfill
Another means of limiting the oxidation of tailings is by mixing the tailings with a binder, usually cement, and using the tailings and cement mixture as backfill in the mine of origin. This tailings management approach is referred to as a paste backfill. Paste backfill limits the oxidation of tailings by creation of a low permeability medium. This, combined with the placement of the tailings back into the mined out voids in an underground mine, limits exposure of the tailings to oxygen during active mining. Upon closure of the mine when the underground voids are allowed to reflood, the cemented tailings are permanently covered in water which further limits oxidation in a manner similar to that described for subaqueous disposal. Where feasible, this method of tailings management has become common industry practice and is a safe and stable means of managing sulfide tailings. This tailings management approach, however, must also be weighed against other mining waste management needs for mines and mills where development rock storage may also be required.

2.4.1.2 Evaluation of Tailings Management Alternatives

Storage of tailings in a surface facility involves preparing a large area, installing a liner and leak collection and detection system, tailings placement, and capping during closure. The surface facility concept is similar to solid waste management. The tailings exiting the mill would have water extracted to a fairly thick but still moist consistency. The moist tailings would be purposefully placed in the facility in sections which would be covered as much as possible during the process.

At the Humboldt Mill site, a surface facility could be located southeast but adjacent to the mill facility, extending into the pre-existing iron ore tailings area (Figure 1-3). The surface facility would be approximately 130 acres.

Use of tailings as a paste backfill in the mine of origin involves mixing it with a binder, usually cement, and pumping the material into mined out stopes in the mine of origin. The tailings volume will exceed the volume of space available for backfill (this is due to bulking). Therefore not all of the tailings can be placed underground, resulting in the need for land-based management of tailings.

Subaqueous tailings impoundment involves pumping tailings in slurry form from the mill to the impoundment area and placing the slurry purposefully below water. At the Humboldt Mill site, the existing HTDF will serve as this impoundment area. The HTDF is the excavated Humboldt iron ore mine, which is now filled with water from groundwater and precipitation. The HTDF was converted to a tailings disposal facility when tailings were placed in it from processing ore from the Ropes Mine.

While the geochemical considerations strongly indicate that subaqueous disposal of sulfide tailings is the best tailings management approach, Table 2-1 compares a range of criteria that were considered in evaluating and selecting a tailings management plan for the Humboldt Mill. The analysis presented in Table 2-1 demonstrates that subaqueous disposal is the preferred alternative for the Humboldt Mill based on all the criteria that were evaluated.

The advantages of subaqueous tailings disposal make use of the HTDF the preferable tailings management alternative based on the following:

- The HTDF maintains the tailings at all times under water in an anoxic environment. No portion of the tailings can reach conditions supporting significant oxidative reactions.

- The HTDF is currently in place, contains sulfide tailings, and has demonstrated that subaqueous placement of tailings has been successful. This is supported by data on the anoxic hypolimnion, chemocline, thermocline and water quality in the epilimnion of the HTDF. Placing new tailings in the HTDF does not represent a new use of this facility, whereas a facility placed, constructed, and maintained on the surface will affect a large land area.

- The HTDF provides stable geotechnical and geochemical conditions for placement of tailings during operations and after closure.

- Aesthetically, a surface facility would be a visible structure on the landscape of the project area. The HTDF appearance will remain the same for the foreseeable future.

2.5 Locating the Project Site

Figure 1-2 shows the site location and area roads, major intersection, and north arrow. Access roads are described with directions given in Section 5 of the application that is continued in Appendix A.

2.6 Other Agency Authorizations Required

Other permits relevant to the HTDF are listed in Section 1.4 of this document.

2.7 Compliance

The project commencement is predicated on the approval of other permits under NREPA. The Part 301 permit is one permit needed to begin the overall project. Recommissioning the HTDF will be enabled when other permits to begin the project are approved. The estimated date of activity to recommission the HTDF is June 2009.

2.8 Adjacent/Riparian and Impacted Owners

Figure 1-2 shows property ownership adjacent to the project area. None of the adjacent property owners own any frontage on the HTDF. Contact information for all adjacent and impacted property owners is shown below:

- Jeff P. & Joyce Ogea, 3891 CR FA, Champion, MI 49814
- Thomas & James Kumpu, 4612 Daniel Dr., Crystal Lake, IL 60014
- Holli Forest Products (Dave Holli), 2002 Prairie Ave., Ishpeming, MI 49849
- Christopher & Holly Ray, 2299 CR 601, Champion, MI 49814
- O'Dovero Properties (Peter O'Dovero), 110 Airport Rd., Negaunee, MI 49866
- A Lindberg & Sons Inc. (Roger Crimmins), 560 Mather Ave., Ishpeming, MI 49849
- Humboldt Stone (Roger Crimmins), 560 Mather Ave., Ishpeming, MI 49849
- Edward & Sandra Ogea, 5637 US 41 West, Champion, MI 49814

2.9 Applicant's Certification

No additional information necessary for this section.

2.10 Projects Impacting Wetlands or Floodplains or Located on an Inland Lake or Stream or a Great Lake

Four subsections within this heading of the JPA are applicable to the project and are addressed separately below. The project has been evaluated for wetland impacts as addressed in Section 2.12. The project will not impact regulated floodplains, therefore Section 13 of the JPA form, is not applicable.

Cross sections of the HTDF appear on Figures 2-3 and 2-4. An overall site plan appears in Figure 1-3. Soil erosion and sedimentation control measures are not needed for tailings placement in the HTDF. Fill calculations appear in Appendix E.

A. Projects Requiring Fill
During mill operations, discharge of tailings to the HTDF via slurry is expected to be approximately 225 gpm of slurry (water and solids). The slurry will contain tailings at approximately 60% solids. The expected daily design loading of tailings to the HTDF during operation is estimated at 1,160 tonnes (dry weight). Expected annual solids loading to the HTDF will be approximately 123,000 to 371,000 tonnes (dry weight). Total quantity of tailings that will be disposed of in the HTDF is approximately 2.5 million tonnes.

Tailings will be placed in three separate phase areas beginning in the North (Phase 1) progressing to the south (Phase 2, Phase 3). The HTDF phase development plan is shown on Figure 2-1. The tailings slurry will be subaqueously placed at the bottom in a controlled manner to allow solids accumulation in layers across the floor. This will be accomplished with the use of a floating barge having a discharge boom that can be positioned vertically across the floor (Figure 2-2). This approach of layering tailings will reduce physical mounding. The total estimated volume available in the three areas to elevation 1,475 ft is approximately 5,000,000 cy. Assuming the tailings consolidate to 72% solids, estimated required tailings disposal volume is 2,400,000 cy. Leveling of the tailings after placement will occur over a period of time, due to consolidation and gravity. The surface elevation of the tailings, if complete leveling is assumed, will be near elevation 1,420 ft, leaving approximately 118 ft of water over the tailings based on a surface water elevation of 1,538 ft. Cross sections of anticipated fill dimensions are shown in Figures 2-3 and 2-4. See Section 2.2 for a more detailed description of tailings addition to the HTDF.

C. Riprap
As a result of the tailings loading, approximately 13,500 ft^3 of water per day will be displaced from the HTDF during operations. Displaced water and water run-off from the HTDF will be treated at the WWTP if necessary, before discharging to a wetland north of the HTDF. The discharge area into the wetland will be lined with 12-in riprap (Figure 2-6). The riprap area will be approximately 10 ft wide by 25 ft long by 18-in deep, and will be underlain with geotextile fabric.

J. Intake / Outlet Pipes
A screened intake structure will be installed in the HTDF for providing mill process water. The intake structure will be installed at the location shown in Figure 2-1.

Tailings will be placed at the bottom of the HTDF via a pipeline connected to a diffuser at the discharge outlet (Figure 2-2). The tailings slurry will be subaqueously placed at the HTDF bottom with the use of a floating barge having a discharge boom that can be positioned vertically across the floor. The barge will move in such a manner that the tailings will be uniformly distributed on the HTDF bottom.

A screened intake pipe for the WWTP will be installed in the HTDF at the location shown in Figure 2-1. A discharge pipe from the WWTP will be located in the wetland area as shown in Figure 2-5. Details for the WWTP intake and discharge pipes are shown in Figure 2-6.

M. Other
A low permeability cut-off wall will be constructed at the north end of the HTDF to prevent HTDF water from mixing with groundwater present in the alluvial soil at the location shown on Figure 1-3. The cut-off wall will extend approximately 1,800 linear feet and will be keyed to the bedrock outcrop near elevation 1,543 ft. KEMC is considering different cut-off wall construction techniques, including cut/fill methods and vibratory beam injection methods. Both of these methods have been successfully used in similar type conditions. As shown in Figures 2-1 and 2-5, some grading will be needed at the north perimeter of the HTDF to establish a surface elevation at or above elevation 1,543 ft. By meeting that elevation, the HTDF exceeds the capacity required for a 24 hr, 100-yr storm event.

2.11 Expansion of an Existing or Construction of a New Lake or Pond

This section does not apply to the HTDF.

2.12 Activities That May Impact Wetlands

Water displaced from tailings placement in the HTDF will be treated at the WWTP if necessary, before discharging to a wetland (Wetland EE) north of the HTDF. Approximately 13,500 ft^3 of water per day will be displaced from the HTDF during operations. Over the seven to eight year operating period approximately 175,000,000 to 200,000,000 ft^3 of water will be released from the HTDF including water displaced from tailings placement and released from natural precipitation events.

A wetland assessment has been completed for the area north of the HTDF. Wetland EE was investigated in a survey performed by King & MacGregor Environmental, Inc. (KME) in 2007. The survey is documented in Appendix C-1. Wetlands 1 through 8 were delineated by KME in

September 2008. The investigations and delineations were conducted in accordance with Michigan's rules, regulations, guidance documents, and general practices. The survey for wetlands 1 through 8 is documented in Appendix C-2.

Wetland EE lies north of the HTDF and extends northeast to the Middle Branch Escanaba River. The portion of Wetland EE south of Highway 41 was flagged by KME and is shown on Figure 2-5. The flagged portion of Wetland EE is approximately 11.8 acres. This wetland is an emergent/scrub-shrub wetland and is part of a wetland complex extending offsite and consists of emergent, scrub-shrub, and forested components. The wetland complex is bisected by US Highway 41 and an old railroad bed. Although Figure 2-5 does not indicate the connection, Wetland EE is hydrologically connected to the Middle Branch Escanaba River through surface water drainage.

Vegetation identified in Wetland EE includes blue-joint (*Calamagrostits Canadensis*), aquatic sedge (*Carex aquatilis*), strict sedge (*Carex stricta*), European horsetail (*Equisetum sylvaticum*), soft rush (*Juncus effuses*), American water-horehound (*Lycopus americanus*), petioled willow (*Salix petiolaris*), balsam willow (*Salix pyrifolia*), wool-grass (*Scirpus cyperinus*), white meadow-sweet (*Sparea alba*), and broad-leaved cattail (*Typha latifolia*). The soils are described in the SSURGO database as Histosols and Aquents – ponded, a poorly drained soil type, and Kinross muck, another poorly drained soil type. The standing water present over the entire wetland during the on-site evaluation indicates the soil conditions are consistent with the SURRGO description.

Upland areas adjacent to Wetland EE have been disturbed by historical mining activities. A large lean ore and waste rock pile is directly west of wetland EE (Figure 1-3). Vegetation in upland areas include sugar maple (*Acer saccharum*), spotted knapweed (*Centaurea maculosa*), Queen Anne's lace (*Daucus carota*), Canada mayflower (*Maianthemum canadense*), white pine (*Pinus strobes*), quaking aspen (*Populus tremuloides*), black cherry (*Prunus serotina*), and bradkenfern (*Pteridium aquilinum*). There was no evidence of standing water or saturated soils in the upland areas.

During operation and after reclamation, the presence of the cut-off wall and berm at the north end will change the HTDF discharge to Wetland EE from the current seepage of groundwater to a surface water discharge at the same location. However, as documented in Appendix F, this discharge will have little effect on water levels in the wetland and therefore will not hydrologically affect the plant community. Furthermore, since the water that will be discharged will comply with water quality standards specified in the NPDES Permit, water quality in the wetland will be protected.

Wetlands 1 through 8 (Figure 2-5) were delineated by KME in September 2008. The wetland delineation evaluation of wetlands 1 through 8 is provided in Appendix C-2. The flagged portions of wetlands 1 through 8 encompass approximately 0.45 acres. To construct the low-permeability cut-off wall and berm (Figure 1-3 and 2-5) grading will be required south of Wetland EE. Construction of the low permeability cut-off wall not will occur in any portion of wetlands 1 through 8. Therefore, a permit under Part 303 of NREPA will not be required for these activities. Wetlands 1 through 8 will not be affected by the proposed structures, as illustrated in Figure 2-5. Grading and installation of the cut-off wall and berm will not commence until all permits are acquired.

An aquatic study of Wetland EE is provided in Appendix C-3.

2.13 Floodplain Activities

Based on a FEMA map search performed by Foth on June 25, 2007, no floodplain mapping has been completed for this area. The proposed project has no construction or operational activities that will change or affect the hydrology of the Middle Branch Escanaba River. Therefore the existing floodplains of these rivers will not be affected by the project.

2.14 Bridges and Culverts

This section does not apply to the HTDF.

2.15 Stream, River, or Drain Construction Activities

This section does not apply to the HTDF.

2.16 Drawdown of an Impoundment

This section does not apply to the HTDF.

2.17 Dam, Embankment, Dike, Spillway, or Control Structure Activities

A low permeability cut-off wall will be installed at the north end of the HTDF to prevent HTDF water from mixing with groundwater present in the alluvial soil (Figure 2-1 and 2-5). Grading will be required along the southern edge of the wetland to construct the cut-off wall. Riprap will be installed at the discharge pipe from the WWTP. A drawdown of the HTDF will not be required to complete the construction of these devices.

Installation of the cut-off wall is part of the *Humboldt Mill Mining Permit Application* (Foth, 2008a) and falls under the professional engineering review of:

Mr. John Starke, P.E. (Michigan Professional Engineer License No. 6201052283)
Foth Infrastructure & Environment
2737 South Ridge Road, Suite 600
Green Bay, WI 54307

2.18 Utility Crossings

This section does not apply to the HTDF.

2.19 Marina Construction and Operating Permit Information

This section does not apply to the HTDF.

2.20 High Risk Erosion and Critical Dune Areas

This section does not apply to the HTDF.

2.21 Activities in Designated Environmental Areas

This section does not apply to the HTDF.

3. Environmental Assessment

The environmental assessment described in this section addresses existing conditions and potential affects due to the proposed use of the HTDF. This section addresses the requirements of 324.30106 of NREPA and R 281.814.

3.1 Existing Conditions

The existing environmental conditions of the HTDF have been evaluated through the characterization of hydrologic, geochemical and biological characteristics of the environment surrounding the HTDF. Appendix B contains a report on the hydrologic and geochemical characterization of the HTDF. The Appendix B report also contains a numerical model that assesses the impact on water quality within the HTDF due to the proposed placement of new tailings in the facility.

Appendix C contains a series of reports documenting the biological characteristics of the HTDF and wetland and aquatic environment downgradient of the outlet from the HTDF. Specifically, Appendix C-1 and C-2 contain evaluations of the wetlands on the north side of the HTDF. Wetland EE currently receives surface water drainage from the HTDF and is discussed in Appendix C-1. Wetland EE will continue to receive discharge from the HTDF in accordance with this proposal. However, the discharge from the HTDF under this proposal will be through controlled point of discharge that includes provisions for water treatment, if necessary, to comply with water quality standards. Appendix C-2 identifies wetlands 1 through 8 which exist on the northern edge of the HTDF in the area of the proposed cut-off wall and berm. Appendices C-3, C-4 and C-5 contain a series of aquatic studies on the HTDF and Wetland EE.

3.1.1 Geology and Hydrogeology and Water Chemistry

This section discusses the geology and hydrogeology of the HTDF. The geology is presented in Section 3.1.1.1, the groundwater hydrology in Section 3.1.1.2, the surface water hydrology in Section 3.1.1.3 and HTDF water chemistry in Section 3.1.1.4.

3.1.1.1 Geology

The existing surficial geology is predominantly sand, gravel and rock fill, and iron ore tailings, overlying and adjacent to deposits of native sand and gravel. Isolated, low-relief bedrock exposures can be seen south of the mill buildings, but the ridge north of the mill buildings is predominantly bedrock-supported with a variable but generally thin veneer of glacial till and minor outwash sand (Figure 3-1). The depth to bedrock in the area ranges from greater than 50 ft below grade, to zero feet, where it is exposed at the surface. Fine to coarse sand, gravel, cobbles, boulders and waste rock from the Humboldt Mine was used to fill a wetland south of the ridge for construction of the former Humboldt Mine offices and mill facilities.

A seismic refraction survey conducted in 1984 provides indirect subsurface information that a buried bedrock valleys exist both north and south of the HTDF (Figure 3-2). Direct subsurface information for this area is based on eleven monitoring wells constructed between 1984 and 1992. Three of the wells are located to the south of the HTDF and eight wells are distributed in an east-west arc to the north of the HTDF. Based on the geologic cross sections, these valleys have been filled with outwash composed of fine- to medium-grained sand with variable amounts of clay and gravel, as displayed in Figures 3-3 through 3-5.

The former Humboldt Mine was developed in a narrow valley, floored by iron-rich rocks, that cuts through a ridge of silicified, dense, recrystallized sedimentary and mafic intrusive rocks. The east and west sides of the pit are poorly fractured bedrock overlain by a thin, patchy till, and provide very little observed subsurface inflow in to the pit.

Foth conducted a bathymetric survey of the HTDF in May 2007, the results of which are shown in Figure 3-6. The HTDF covers an area of 269,400 m^2 (67 Ac) at a normal elevation of 468.8 m (1538 ft), with a total volume of 7,997,216 m^3. Depths in the main HTDF area are over 20 m (66 ft) for roughly two-thirds of the main HTDF surface area, and are 58.5 m (192 ft) at the deepest point. Depths in the northern HTDF area are limited to less than 20 m, and less than 7 m at the confluence with the main HTDF area.

Prior to construction of the former Humboldt Mine in 1954, this area was a wooded wetland divided by isolated upland areas and low bedrock exposures (Figure 3-7). In order to construct the mill, the wetlands were filled with the unconsolidated material from the intervening uplands and development rock taken out of the former Humboldt Mine.

3.1.1.2 Groundwater Hydrology

Contoured groundwater elevations from June 2007 are shown on Figure 3-8. The highest groundwater elevation is found near MW-602 at the northern-most portion of the iron ore tailings basin. The lowest groundwater elevation was recorded in the wetland north of the HTDF at well HW-6. The depth to groundwater varies from less than 10 ft bgs east of the mill buildings, to greater than 38 ft bgs near the south end of the HTDF.

To the west of the Humboldt Mill, the slope of the water table changes from southerly toward the West Branch of the Black River to northerly into the HTDF. Although groundwater south of the ridge generally flows south, the HTDF is drawing groundwater in the alluvium from south of the HTDF. Given the lack of significant groundwater within the bedrock flanking the HTDF, the predominant groundwater flow into the pit is from the south, through more than 40 feet of sand and gravel outwash. The deformation and foliation of the bedrock surrounding the HTDF has served to produce a weakly jointed bedrock surface. Sheared and recrystallized contacts at depth would likely limit joint propagation. In addition, due to the interlocking recrystallized texture, storage will be limited to the joint network. Recrystallized formations without a well developed joint network are very poor groundwater producers.

It is important to recognize that almost all of the potential groundwater flowing into the HTDF at its southern end is from outside the drainage basin of the HTDF, as the perimeter of the drainage basin falls very close to the perimeter of the pit in this location. Therefore, this input is distinct from, and in addition to, the rain input in the drainage basin. Thus, the site survey and recent groundwater monitoring strongly indicate that groundwater from a small area south of the HTDF flows into the southern end of the HTDF

Water flows out of the north end of the HTDF through approximately 40 feet of outwash and enters a wetland before discharging to the Middle Branch of the Escanaba River. Groundwater in the vicinity of the HTDF is recharged from the infiltration of precipitation on the small area to the south and south west of the HTDF.

Groundwater in the vicinity of the Humboldt Mill is recharged from precipitation and runoff from the bedrock ridge to the north. Groundwater in the vicinity of the Humboldt Mill discharges predominantly towards Lake Lory and the Black River.

3.1.1.3 Regional Surface Water Hydrology

The site is situated near the drainage divide between sub-watersheds of the Escanaba River, which flows southeast into Lake Michigan. Prior to construction of the former Humboldt Iron Mine, the divide followed the prominent east-west ridge north of the Humboldt Mill. After mining had ceased, groundwater entered the HTDF from both the north and south ends. After the pit filled with water, pit water discharged to the north into the Middle Branch Escanaba River. Therefore the watershed divide effectively migrated south to the southern edge HTDF, as displayed in Figures 1-4 and 3-6.

A detailed site survey of HTDF conducted in April, 2007 by a Foth geologist concluded that only minor seasonally ephemeral flows leave the HTDF by seepage through an earthen dam on the north side of the HTDF. Visual inspection suggested that a substantial portion of the discharge occurs through the coarse materials near the surface, estimated to be from 100 to 150 gpm.

3.1.1.4 HTDF Water Chemistry

The water chemistry of the HTDF has been extensively characterized. Section 4 of the report in Appendix B provides data documenting the following:

- Characteristics of the thermocline and chemocline in the HTDF including seasonal persistence of thermocline and chemocline.
- Depth profiles of dissolved constituents.
- HTDF chemical limnology, including acid-base and redox chemistry, and complexation and precipitation chemistry.
- Major and minor chemical species in the HTDF, including alkalinity and carbon chemistry.
- Profiles of dissolved oxygen relative to primary productivity within the HTDF.
- HTDF oxidation – reduction chemistry that modulates the concentration of various constituents in water of the HTDF.
- Sulfide mineral chemistry that affects constituent concentrations in waters of the HTDF.
- Iron cycling that attenuates metal concentrations within the HTDF epilimnion.

3.1.2 HTDF Wetlands

Appendix C-1 documents that Wetland EE along the northern end of the HTDF is an emergent/scrub-shrub wetland approximately 11.8 acres in size within the surveyed area. Water in Wetland EE drains into the Middle Branch Escanaba River through a wetland complex bisected by U.S. Highway 41 as displayed in Figure 2-5. The report in Appendix C-1 documents the vegetative composition of the wetland and notes that no listed species were observed during field activities.

Appendix C-2 documents eight additional small wetland and areas (wetlands 1 through 8) on the northern end of the HTDF. The eight small wetland areas encompass a total area of approximately 0.45 acres. No delineated wetlands will be impacted during the installation of the proposed cut-off wall and berm.

3.1.3 Aquatic Biology

Appendix C-4 documents the aquatic habitat characteristics in the HTDF. The Appendix C-4 report, combined with water chemistry data discussed in Section 4 of the Appendix B report, documents the following:

- No listed species were observed in the HTDF.
- The fish community within the HTDF is comprised of sparse populations of minnows, small white suckers and northern pike.
- The bedrock dominated habitat in the littoral area of the HTDF and lack of habitat diversity, including few macroinvertebrates, do not provide suitable conditions for abundant and diverse aquatic community within the HTDF.
- Dissolved organic carbon averages approximately 2 mg/l, consistent with an oligotrophic system and low primary productivity.
- Diurnal dissolved oxygen profiles strongly indicate that photosynthesis, and therefore primary production, is not occurring in the HTDF.
- The water chemistry data combined with the aquatic habitat data demonstrate that the HTDF is not exhibiting primary production that supports a diverse and functioning aquatic biological community.

Appendix C-5 provides data on metal concentrations in fish from the HTDF. Overall the metal concentrations in fish samples from the HTDF were not uniformly elevated in comparison to Lake Lory.

Appendix C-3 contains a report on the aquatic habitat of Wetland EE. No listed species were observed in Wetland EE. Wetland EE and the stream draining it are considered “poor” quality for fish. A limited macroinvertebrate community was also documented.

3.2 Environmental Impact Assessment

The proposed action seeks to place tailings in the existing HTDF. Pertinent features of the proposed action include:

- Installation of a containment wall in the unconsolidated deposits on the north side of the HTDF to eliminate subsurface migration of water.

- Controlled placement of tailings on the bottom of the HTDF, an artificial water body.

- Controlled release of water from the HTDF through a WWTP that will be designed to treat, if necessary, the excess HTDF water prior to discharge into Wetland EE.

- Maintenance of the WWTP after mill closure so that, if needed, there is a means to treat water from the HTDF until water quality in the epilimnion of the HTDF returns to levels that meet water quality standards.

The report provided in Appendix B contains modeling documentation that examines the impact on water quality in the HTDF due to tailings placement. From a water quality and treatment perspective, the WWTP proposed in the NPDES permit (Foth, 2008b) is based on the worst case scenario and is designed to comply with estimated effluent limits for discharge to Wetland EE.

The modeling analysis presented in Appendix B also demonstrates that the HTDF is likely to stay stratified during operations, thereby maintaining compliance with water quality standards in the epiliminion negating the need for water treatment. Thus, the WWTP will be in place as a contingency for treatment during operations and after closure, if needed.

Furthermore, since the HTDF is an artificial body of water, there are no riparian rights associated with it. Additionally, all the land surrounding the HTDF is owned by the applicant. The HTDF is also not subject to the public trust since it is not a navigable water. The HTDF is a privately-owned facility with no public trust access and no natural inlet or outlet to public waters. Therefore, there are no public rights associated with the HTDF.

There is currently no recreational use of the facility. The fish and wildlife habitat are minimal as described in the biological studies included in Appendix C. The aesthetics of the area do not change by tailings placement in the HTDF as the original water elevation will remain stable during the placement of tailings. No agriculture is affected by the facility. The local government gains taxes and the commercial impacts of additional workers, suppliers and economic activity benefits the local community. The HTDF and receiving water quality at the outlet of the HTDF will not be impacted by the tailings placement.

Overall, all the engineering features described will allow KEMC to operate and close the HTDF in a manner that maintains compliance with water quality standards at Wetland EE. In addition, since there is no primary productivity within the HTDF, there will be no impact to a self-sustaining biological community.

The use of the HTDF for tailings placement represents a best practice approach for tailings management with virtually no new environmental impact. The HTDF, currently in place, contains sulfide tailings. Because the tailings are under water at all times in an anoxic environment, they cannot support significant oxidative reactions. The existing HTDF has demonstrated that subaqueous placement of tailings has been successful. Based on this and KEMC's engineering plans for the HTDF, it is reasonable to conclude that KEMC's plans for tailings placement in the HTDF will protect the environment.

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Tables

Table 2-1
Comparison of Tailings Management Alternatives

	Potential to Oxidize	Potential to Acidify	Fugitive Dust	Geotech Stability	Successful Implementation i.e. Examples	Best Practice	Site Availability	Relative Impact to Features (Flora, Fauna, Aesthetics, etc)	Transportation	Overall Cost	Average
Paste Fill	2	3	3	3	3	2	1	3	1	1	2.2
Dry Stack	2	2	2	3	3	2	3	2	2	2	2.3
Subaqueous	3	3	3	3	3	3	3	3	3	3	3

Scale: 1-3

A number between 1 and 3 was assigned for each criterion that was considered in comparing the three alternatives. For each criterion considered a 3 was assigned to the best alternative, a 2 was assigned to the next best alternative and 1 was assigned to the last remaining alternative. For any given criterion in which two of the alternatives were considered equal, a 2 or 3 was assigned to the alternative. If all three alternatives were considered equal a 3 was assigned to all alternatives.

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